A SURVEY OF AERATED LAGOON PERFORMANCE

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ABSTRACT

A survey of five wastewater treatment systems was carried out to determine if completely mixed aerated cells or aerated facultative cells are viable means of pre-treatment for organic load reduction to existing stabilization ponds. Substantial reductions in BOD_5 and suspended solids are being achieved by the aerated pre-treatment cells. It was found, however, that the pre-treatment cells do not prevent anaerobic conditions in the stabilization ponds that follow during periods of ice and snow cover. Conversions of the stabilization ponds to aerated facultative ponds by means of sub-surface aeration or post-treatment for H_2S removal may therefore be necessary. In regards to NH_3-N_2 the pre-treatment cells will not achieve appreciable reductions unless they are modified to achieve complete nitrification throughout the year.

1.0 Introduction

About one hundred and thirty wastewater treatment systems in Ontario consist of waste stabilization ponds (lagoons). In the past, the availability of inexpensive land and low operating and maintenance costs made these systems attractive to many rural communities. Recently many of these systems have become overloaded and require some means of upgrading, and land constraints often prohibit the expansion of the lagoon system. The construction of an aerated facultative or completely mixed aerated cell ahead of the lagoon system can be used to reduce the organic load to the existing system. During 1976, six such installations were operated by the Ontario Ministry of Environment. This study examines five of these treatment systems.

Operation and maintenance of existing aerated lagoon systems, and lagoons in general, is usually carried out on a part-time basis, and regular sampling and testing is seldom performed. A meaningful performance evaluation based on available operating records is hence very difficult. A sampling and testing program was therefore carried out at five facilities located within 160 km (100 miles) of Toronto. The locations selected are described in numerical order.

Treatment facility # I was designed as a completely mixed aerated cell discharging directly to the receiving stream. Facility # II employs a completely mixed aerated cell followed by two stabilization ponds. The other three systems each consist of an aerated facultative cell followed by one or more conventional waste stabilization ponds that can be operated in series or parallel and in a continuous discharge or seasonal detention mode.

2.0 Objectives

The purpose of this study was to evaluate a number of existing aerated cells with the intention of optimizing design criteria and operating procedures for such treatment facilities.

3.0 Sampling And Testing

One day visits were made to three of the five locations during March 1976 to observe late winter operation. Grab samples were collected and dissolved oxygen readings taken where possible.

Three to five days of sampling and testing were carried out at each facility during June and July, 1976. Since the processing schedules of the local industries depend on the fruit and vegetable growing season, the surveys were repeated at locations II, III, IV and V during August, October and November.

During the three to five day sampling periods, composite samples over 24 hours were taken of the raw sewage, the effluent of the aerated cell and the effluents or contents of the waste stabilization ponds. A number of grab samples were also taken at all sampling locations in an attempt to establish peak loading periods. On-site tests during the three to five day sampling programs included dissolved oxygen, temperature, oxygen utilization rates, pH and measurement of bottom sludge accumulations.

4.0 Evaluation Of Treatment Facility # I

4.1 Description Of Works

This facility was designed as a completely mixed aerated cell with effluent discharge directly to the receiving stream. The system was designed to achieve an effluent with BOD_5 and suspended solids concentrations of 15.0 mg/L each. A quiescent zone is provided ahead of the effluent overflow weir to reduce effluent suspended solids. The four platform-mounted surface aerators at 3.73 kW (5.0 HP) each have a total oxygen transfer rating of 25.5 kg O_2/h (56 lbs O_2/hr) and provide $2.6X10^{-3}$ kW/m^3 (0.1 HP/1,000 cu ft) for mixing.

The aeration cell has a volume of 5,579 m^3 (197,000 cu ft) and provides 4.2 days detention at the design flow of 1,318 m^3/d (290,000 IGPD).

The design organic load is 48 g BOD_5/m^3/d (3.0 lbs BOD_5/1,000 cu ft/day) based on 3,450 persons x 77 g BOD_5/cap/d. At the time of the survey, phosphorus removal was not practiced at this location.

4.2 Sampling Survey

Only one survey was conducted at this treatment facility since significant changes in sewage flows and strength were not expected during the dry weather period.

The survey was carried out from June 21 - June 23, 1976. Composite samples over 24 hours were taken of the raw sewage, the aeration cell content (mixed liquor) and the aeration cell effluent. Onsite tests included pH, temperature, dissolved oxygen, oxygen utilization rates and bottom sludge depth measurements.

4.2.1 Results And Discussion

From the analytical results presented in Tables I, II and III an average aeration cell detention time of 6.5 days and an average organic load of 21 g $BOD_5/m^3/d$ (1.3 lbs BOD_5/1,000 cu ft/day) was calculated for the sampling period. Although the organic load was well below the design load of 48 g $BOD_5/m^3/d$ (3.0 lbs BOD_5/1,000 cu ft/day) reductions in BOD_5 and suspended solids were only 67% and 62.4% respectively with corresponding effluent concentrations of 44 mg/L BOD_5 and 94 mg/L SS. It is noteworthy, however, that the effluent soluble BOD_5 averaged 4.0 mg/L, indicating that a reduction in effluent suspended solids would substantially improve the effluent quality. It is also of interest that facility # I was the only aerated cell that achieved nitrification during the summer months. It is assumed that the low organic load coupled with increased solids retention were mainly responsible for this occurrence. The higher SRT's were accomplished by the partial clarification of the effluent within the quiescent zone ahead of the effluent weir. Samples taken in March 1976 indicated that very little nitrification occurs during the colder months.

Complete mixing was not accomplished in the aeration cell since bottom sludge accumulations of 0.5 m - 1.2 m (1½ - 4 feet) were measured with the heaviest sludge blanket about 6 m (20 feet) away from the aerators. The total of 15 kW (20 HP) used for aeration and mixing translates to about 2.6×10^{-3} kW/m^3 (0.1 HP/1,000 cu ft) of aeration basin, normally considered too low to provide complete mixing. Dissolved oxygen readings close to zero near the cell bottom also indicated incomplete mixing. Dissolved oxygen concentrations of about 6.0 mg/L were maintained at most sampling points to a depth of 2.45 m - 2.75 m (8 - 9 feet). The total liquid depth was 3.05 m (10 feet).

TABLE I

FACILITY #1 - RAW SEWAGE - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	Flow m^3/d	BOD_5 Loading kg/d	pH
June 21/76	136	34	336	215	182	18	40	6.4	340	0.4	.02	764	104	8.0
June 22/76	144	39	478	287	251	18	32	6.0	336	0.3	.02	732	105	8.0
June 23/76	136	32	374	249	205	40	64	9.1	404	0.3	.01	1,069	145	8.2
Average	139	35	396	250	213	25	45	7.2	360	0.3	.02	855	118	8.1

FACILITY #1 - RAW SEWAGE- GRAB SAMPLES

June 22/76	112	35	283	161	129	41	63	7.5	440	.3	.01			
June 23/76	136	32	374	249	205	40	64	9.1	404	.3	.01			

Unless indicated otherwise, all units, except pH, are mg/L

TABLE II

FACILITY #1 - AERATION CELL CONTENT (MIXED LIQUOR) - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 21/76	57	5	137	122	82	.1	9.0	6.0	204	18	2.2	8.0
June 22/76	58	6	176	141	96	.1	11	6.2	204	17	1.9	8.0
June 23/76	62	5	150	164	104	.1	12	6.0	204	17	1.9	7.9
Average	59	5	154	142	94	.1	10.7	6.1	204	17	2.0	8.0
FACILITY #1 - AERATION CELL CONTENTS (MIXED LIQUOR) - GRAB SAMPLES												
June 22/76	51	4	119	110	76	0.3	9.0	5.8	204	18	2.5	
June 23/76	50	3	136	102	70	0.2	8.4	5.6	204	19	.84	

Unless indicated otherwise, all units, except pH, are mg/L

TABLE III

FACILITY #1 - AERATION CELL EFFLUENT (FINAL EFFLUENT) - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 21/76	39	4	99	82	58	.1	7.6	5.4	208	18	1.9	8.0
June 22/76	37	3	118	85	59	.1	6.4	5.4	204	19	1.5	7.9
June 23/76	56	4	127	115	79	.1	10	5.6	200	17	2.0	7.9
Average	44	4	115	94	65	.1	8.0	5.5	204	18	1.8	7.9
FACILITY #1 - AERATION CELL EFFLUENT (FINAL EFFLUENT) - GRAB SAMPLES												
June 22/76	37	4	93	79	52	0.1	6.0	5.2	204	19	2.1	
June 23/76	39	3	117	77	54	0.1	6.8	5.6	204	19	1.2	

Unless indicated otherwise, all units, except pH, are mg/L

Oxygen utilization rates of the aeration cell contents were too low to be measured accurately.

4.3 Conclusions And Recommendations

1. The aeration cell at the treatment facility # I was not able to produce an effluent of an acceptable quality for direct discharge at organic loadings of less than one-half the design load of 48 $g/m^3/d$ (3.0 lbs BOD_5/1,000 cu ft/day).
2. Actual oxygen transfer efficiency of the four 3.7 kW (5 HP) mechanical aerators could not be determined since oxygen utilization rates were too low to be measured accurately.
3. The aeration equipment was not capable of providing complete mixing since bottom sludge accumulations of one to four feet deep were measured and dissolved oxygen stratification was noticed within the cell. The applied mixing horsepower of 2.6×10^{-3} kW/m^3 (0.1 HP/1,000 cu ft) of aeration cell volume is generally not acceptable for complete mixing. In regards to effluent quality, incomplete mixing was probably beneficial at this facility, since reduced effluent suspended solids concentrations resulted.
4. It is assumed that the low organic load applied and the prolonged SRT's due to the provision of a quiescent zone for effluent suspended solids reduction resulted in nitrification during the summer months.
5. The addition of a polishing pond and the use of chemicals ahead of the pond for phosphorus removal and improved solids removal should result in an effluent of acceptable quality.

5.0 Evaluation Of Treatment Facility # II

5.1 Description Of Works

The waste treatment facility # II consists of a completely mixed aeration cell followed by two waste stabilization ponds with a total surface area of 30 ha (74 acres). The stabilization ponds can be operated in series or in parallel. The combined wastes from the town and a food processing company are pumped directly to the aeration cell. The design maximum BOD_5 load (1990) is 2,026 kg/d (4,458 lbs/day) resulting in an organic load of 117 g $BOD_5/m^3/d$ (7.3 lbs BOD_5/1,000 cu ft/day) to the aeration cell. Aeration is provided by three floating surface aerators rated at 22.4 kW (30 HP) each. The aerators are designed to deliver a total of 79.5 kg/h (175 lbs O_2/hr) and to maintain a minimum dissolved oxygen level of 1.5 mg/L throughout the aeration cell. The aeration cell volume is 17,332 m^3 (612,000 cu ft) providing 3.5 days hydraulic detention at a raw sewage flow of 4,910 m^3/d (1.08 MIGD). The aerators provide $3.9x10^{-3}$ kW/m^3 (0.15 HP/1,000 cu ft) of aeration cell for mixing. Alum is injected into the raw sewage forcemain for phosphorus precipitation.

5.2 Survey # 1

The first sampling survey was carried out at this treatment facility from July 6 to July 9, 1976. The system was being operated in series and addition of alum to the raw sewage for phosphorus removal had commenced on July 1, 1976. Effluent was not being discharged to the receiving stream as the contents of the final waste stabilization pond were being disposed of by spray irrigation. Refer to Tables IV, V, VI and VII for results.

TABLE IV

FACILITY #II - RAW SEWAGE - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	Flow m^3/d	BOD_5 Loading kg/d	pH
July 6/76	267	117	489	249	194	1.0	28	3.4	260	.1	.01	5,343	1,427	6.5
July 7/76	316	128	508	250	198	1.8	18	3.8	268	<.1	.01	5,246	1,629	7.6
July 8/76	236	81	418	239	191	2.4	17	3.3	284	<.1	.01	5,110	1,206	7.6
Average	273	109	472	246	194	1.7	21	3.5	270	<.1	<.1	5,205	1,421	7.2
FACILITY #II - RAW SEWAGE - GRAB SAMPLES														
July 6/76	198	107	450	148	117	8.5	21	4.7	292	.1	.01			
July 7/76	184	101	444	150	98	4.3	31	3.2	276	<.1	.02			

Unless indicated otherwise, all units, except pH, are mg/L

TABLE V

FACILITY #II - AERATION CELL EFFLUENT - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
July 6/76	89	29	198	167	99	5.6	42	4.6	320	<.1	.01	7.4
July 7/76	110	34	259	157	117	3.3	18	3.4	316	<.1	.03	7.3
July 9/76	113	30	272	169	128	2.6	19	3.6	308	<.1	.02	7.5
Average	104	31	243	164	115	3.8	26	3.8	315	<.1	<.1	7.4

FACILITY #II - AERATION CELL EFFLUENT - GRAB SAMPLES

July 6/76	82	26	200	100	74	4.4	16	2.9	316	.1	.02	7.5
July 7/76	100	27	245	145	109	3.6	31	3.4	312	<.1	.02	7.4

Unless indicated otherwise, all units, except pH, are mg/L

TABLE VI

FACILITY #II - STABILIZATION POND #1 EFFLUENT - GRAB SAMPLES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
July 7/76	22	9	88	27	23	3.9	30	3.8	324	<.1	.01	7.9
July 6/76	25	7	115	52	47	6.8	14	3.2	328	<.1	.04	8.1
July 8/76	15	8	78	24	21	7.6	13	3.0	328	<.1	.03	8.2
Average	21	8	94	34	30	6.1	19	3.3	327	<.1	<.1	8.1
Nov. 8/76	10	4	54	17	15	7.6	11	0.88	296	.1	.02	8.0
Nov. 9/76	17	3	54	17	15	7.4	11	0.88	296	<.1	0.02	8.0
Nov. 10/76	18	3	56	24	16	7.8	12	0.92	292	.1	.02	8.2
Average	15	3	55	19	15	7.6	11	0.9	295	<.1	<.1	8.1

Unless indicated otherwise, all units, except pH, are mg/L

TABLE VII

FACILITY #II - STABILIZATION POND # 2 EFFLUENT - GRAB SAMPLES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	Total P	TKN	NH_3-N	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
July 6/76	35	5	110	52	46	1.7	15	4.2	276	<.1	.01	7.9
July 7/76	20	5	90	41	35	1.5	8.6	3.3	276	<.1	.06	8.1
July 8/76	22	5	89	35	31	1.3	7.0	2.3	276	<.1	.17	8.1
Average	26	5	96	43	37	1.5	10.2	3.3	276	<.1	< .1	8.0

FACILITY #II - STABILIZATION POND #2 EFFLUENT - GRAB SAMPLES

Nov. 8/76	6	3	45	8	7	1.1	10	6.3	288	.1	.02	8.3
Nov. 9/76	5	3	42	5	4	1.1	9.8	6.6	288	<.1	0.02	8.1
Nov. 10/76	5	4	42	11	4	1.1	9.8	6.8	292	.2	.02	8.2
Average	5	3	43	8	5	1.1	10	6.6	289	<.1	<.1	8.2

Unless indicated otherwise, all units, except pH, are mg/L

5.2.1 Results And Discussion

The BOD_5 load to the aeration cell averaged 1,421 kg/d (3,126 lbs/day) or 81.7 $g/m^3/d$ (5.1 lbs BOD_5/1,000 cu ft/day). The rated total oxygen transfer of the aerators is 79.5 kg/h (175 lbs O_2/hr) or 1,909 kg/d (4,200 lbs O_2/day). Dissolved oxygen concentrations of 0.2 mg/L - 0.5 mg/L were measured in the aeration cell throughout the sampling period. This would suggest that almost all of the oxygen transferred was used up by the waste and would suggest an oxygen requirement of 1.34 kg O_2/kg BOD_5 (1.34 lbs O_2/lb BOD_5) applied.

The oxygen utilization rate for the same period averaged 4.8 mg O_2/L/hr for the aeration cell. This suggests an oxygen transfer of 1,996 kg O_2/d (4,391 lbs O_2/day) or about 0.3 kg/MJ·h (2.0 lbs O_2/HP/hr) and an oxygen demand of 1.4 kg O_2/kg BOD_5 (1.4 lbs O_2/lb BOD_5) applied. Since nitrification did not occur and very little bottom sludge was detected, this oxygen demand can be solely attributed to the raw waste.

At a detention time of 3.3 days, BOD_5 and suspended solids reductions in the aeration cell averaged 62% and 38% respectively. Sludge accumulations of up to 60 cm (two feet) were noticed on the vicinity of the inlet pipe to stabilization pond No. 1. Very little bottom sludge was found at the other sampling locations within the ponds. The average BOD_5 concentration of 104 mg/L in the aeration cell effluent resulted in an organic load of 30.3 kg BOD_5/ha/d (27 lbs BOD_5/acre/day) to the first waste stabilization pond in series. The load to the second pond averaged 8.98 kg BOD_5/ha/d (8 lbs BOD_5/acre/day). Very little algae growth was present in the first pond. Dissolved oxygen concentrations ranged from 0.3 mg/L to 1.7 mg/L. Algae was noticeable in the second pond and 8.0 mg/L - 12.6 mg/L dissolved oxygen was measured.

5.3 Survey # 2

The second sampling survey was conducted from November 9, 1976 to November 12, 1976. The facility was still being operated in series and effluent was being discharged to the receiving stream. Spray irrigation of the effluent had been discontinued due to freezing problems. See Tables VI, VII, VIII and IX.

5.3.1 Results And Discussion

For the sampling period in November, a BOD_5 load of 1,071 kg/d (2,357 lbs/day was calculated for the aeration cell resulting in a load of 62.5 g $BOD_5/m^3/d$ (3.9 lbs BOD_5/1,000 cu ft/day). The oxygen utilization rate of the aeration cell mixed liquor averaged 3.6 mg O_2/L/hr resulting in a total oxygen consumption of 1,497 kg O_2/d (3,293 lbs O_2/day). This represents an oxygen demand of 1.4 kg O_2/kg BOD_5 (1.4 lbs O_2/lb BOD_5) applied. Dissolved oxygen concentration of 2.0 mg/L - 5.0 mg/L were measured in the aeration cell during the same period. At a detention time of 3.6 days the average BOD_5 reduction was 52%. Total suspended solids were actually higher in the aeration cell effluent than in the influent. The addition of about 80 mg/L alum to the raw sewage for phosphorus removal since July 1, 1976 is assumed to be the main cause for the increase in aeration cell suspended solids. No bottom sludge accumulations were noticed within the aeration cell.

Since the two stabilization ponds were operated in series, the BOD_5 loads averaged 28.3 kg/ha/d (25.2 lbs/acre/day) and 5.6 kg/ha/d (5.0 lbs/acre/day) respectively. Dissolved oxygen levels of 7.0 mg/L - 16.0 mg/L were measured in the stabilization ponds. There was a noticeable algae growth within the ponds.

An effluent of good quality was being discharged for the duration of the survey. BOD_5 and suspended solid concentrations averaged 5.0 mg/L and 8.0 mg/L respectively.

TABLE VIII

FACILITY #II - RAW SEWAGE - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	Flow m^3/d	BOD_5 Loading kg/d	pH
Nov. 9/76	147	78	389	195	164	15	28	5.2	328	<.1	.01	4,091	601	7.6
Nov. 10/76	209	60	531	190	164	13	28	8.6	332	.02	0.15	4,773	998	7.4
Nov. 11/76	263	113	544	321	262	7.3	44	9.6	324	.1	.01	4,637	1,219	7.1
Nov. 12/76	270	143	604	218	188	7.2	22	4.5	300	<.1	<.01	5,364	1,448	7.4
Average	222	99	517	231	194	10.6	30	7.0	320	<.1	<.1	4,828	1,071	7.4

Unless indicated otherwise, all units, except pH, are mg/L

TABLE IX

FACILITY #II - AERATION CELL EFFLUENT - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
Nov. 9/76	112	26	376	327	295	9.6	44	5.2	316	<.1	<.1	7.6
Nov. 10/76	100	19	405	336	244	9.1	43	8.6	308	<.1	<.1	7.6
Nov. 11/76	107	14	430	400	216	8.8	51	16.0	308	<.1	<.1	7.4
Nov. 12/76	106	18	320	429	229	6.4	35	7.5	260	<.1	<.1	7.5
Average	106	18	383	373	246	8.5	43	9.3	298	<.1	<.1	7.5

Unless indicated otherwise, all units, except pH, are mg/L

5.4 Conclusions And Recommendations

1. With the present aeration equipment, the completely mixed aeration cell at this facility is capable of reducing the BOD_5 by more than 60% at an average load of about 1,455 kg/d (3,200 lbs BOD_5/day). Prolonged loads in excess of 1,455 kg/d (3,200 lbs BOD_5/day) would probably lead to an oxygen deficiency within the aeration cell that could result in anaerobic conditions and possibly odour problems. The design maximum BOD_5 load is 2,026 kg/d (4,458 lbs/day).
2. The structural design of the floating aerators causes the accumulation of rags and debris onto the support structures and impeller shaft and results in frequent failures of the aerators due to excessive power draw. Icing during winter operation also causes frequent failures and excessive maintenance.
3. The waste stabilization ponds should be operated in parallel to prevent overloading of the first cell in series.
4. Taking into account the detention times, the addition of chemicals for phosphorus reduction should not be necessary for the period the stabilization pond contents are disposed of by spray irrigation.

6.0 Evaluation Of Treatment Facility # III

6.1 Description Of Works

The treatment facility consists of an aerated facultative cell followed by two waste stabilization ponds. The aerated cell has a volume of 5,806 m^3 (205,000 cu ft) at an operating depth of 3 m (10 ft). Two bridge-mounted mechanical aerators rated at 5.6 kW (7.5 HP) each are designed to deliver .5 kg/MJ·h (3 lbs O_2/HP/hr) and to maintain a minimum of 2.0 mg/L dissolved oxygen throughout the liquid phase while allowing solids deposition. The mixing power is 1.8×10^{-3} kW/m^3 (0.07 HP/1,000 cu ft) of aeration cell volume. The maximum design load to the aerated cell is 279 kg/d (614 lbs BOD_5/day) with a corresponding organic load of 48 g BOD_5/m^3/d (3 lbs BOD_5/1,000 cu ft/day). The aeration cell detention time is about 5.2 days at the design flow of 1.125 m^3/d (247,500 IGPD). The stabilization ponds have a total surface area of 7.7 ha (19 acres) and are operated at a liquid depth of 1.5 m (5 feet). Phosphorus removal is being practiced by batch treatment of the lagoon contents prior to spring and fall discharge.

6.2 Sampling Surveys

During the one-day visit in March 1976, the aerated cell and the stabilization ponds were found to be void of dissolved oxygen. Hydrogen sulfide odours were noted in the vicinity of the aerated cell and at the final effluent overflow weir. At the time of the visit the aerated cell was ice-covered except around the aerators. The stabilization ponds had a complete cover of ice and snow.

6.2.1 Survey # 1

A 3-day sampling and testing program was carried out from June 28, 1976 - June 30, 1976. The system at that time was being operated in series without effluent discharge (seasonal detention). Composite samples over 24 hours and grab samples were taken of the raw sewage, the aeration cell contents and effluent, and the effluent of the first stabilization pond in series. Since the second stabilization pond was filling up, grab samples were taken at the effluent end of that pond. Refer to Tables X - XIV inclusive.

6.2.2 Results And Discussion

The aerated cell was void of dissolved oxygen for the duration of the survey. Anaerobic conditions had developed and hydrogen sulfide odours were noticeable in the vicinity. The composite and grab samples taken of the raw sewage indicate that wastes with high BOD_5 and suspended solids concentrations are discharged to the sewer system periodically. Although the average BOD_5 load for the sampling period was 268 kg/d (591 lbs/day), and thus less than the design value of 279 kg/d (614 lbs/day), extreme variations were noticed, i.e. 193-399 kg/d (425-879 lbs/day). The corresponding organic load to the aeration cell averaged 46.5 g $BOD_5/m^3/d$ (2.9 lbs BOD_5/1,000 cu ft/day) and ranged from 34-70 g $BOD_5/m^3/d$ (2.1-4.3 lbs/1000 cu ft/day). Assuming an oxygen demand of 1.5 kg $O_2/kg \cdot BOD_5$ (1.5 lbs O_2/lb BOD_5) applied, the 268 kg BOD_5/d (591 lbs BOD_5/day) would require 402 kg O_2/d (887 lbs O_2/day), well within the aerators design capacity of 490 kg O_2/d (1,080 lbs O_2/day). The oxygen utilization rate of aeration cell mixed liquor, however, averaged 4.4 mg O_2/l/hr resulting in a total oxygen demand of 610 kg O_2/d (1,344 lbs O_2/day) and this demand exceeded the oxygen transfer capacity of the two aerators. It seems that the combination of the periodic over loading of the system prior to the survey and the

TABLE X

FACILITY #III - RAW SEWAGE - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	Flow m^3/d	BOD_5 Loading kg/d	pH
June 28/76	514	52	1297	881	716	19	48	10.0	364	.1	.01	778	399	8.3
June 29/76	266	65	1591	636	571	10	28	5.8	416	.1	.01	801	213	8.2
June 30/76	247	94	513	389	295	7.5	25	5.6	316	.1	.01	783	193	8.0
Average	342	70	1133	635	527	12	34	7.1	365	.1	.01	787	268	8.2
RAW SEWAGE - GRAB SAMPLE														
June 29/76	630	415	1182	497	445	17	42	6.2	304	.6	.02			

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XI

FACILITY #III - AERATION CELL (MIXED LIQUOR) - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 28/76	120	61	372	274	142	22	36	6.8	436	.1	.01	7.7
June 29/76	83	24	263	183	115	17	30	6.0	416	.1	.01	7.6
June 30/76	96	49	280	122	92	19	32	5.8	420	.1	.01	7.6
Average	100	45	305	193	116	19	33	6.2	424	.1	.01	7.6
AERATION CELL (MIXED LIQUOR) - GRAB SAMPLES												
June 29/76	127	87	259	101	80	21	34	6.2	424	.1	.02	
June 30/76	107	73	288	94	75	20	32	5.8	432	.1	.01	

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XII

FACILITY #III - AERATION CELL EFFLUENT - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 28/76	104	65	296	124	97	22	35	6.6	432	<.1	.01	7.7
June 29/76	101	65	285	113	92	20	33	5.8	420	.1	.01	7.6
June 30/76	131	60	297	168	129	19	34	6.0	424	<.1	.01	7.6
Average	112	63	293	135	106	20	34	6.1	425	<.1	.01	7.6
AERATION CELL EFFLUENT - GRAB SAMPLES												
June 29/76	99	78	305	112	84	22	34	6.4	420	<.1	.02	7.6
June 30/76	115	73	285	92	74	20	32	5.8	428	.1	.01	7.6

Unless indicated otherwise, all units except pH, are mg/L

TABLE XIII

FACILITY #III - STABILIZATION POND #1 EFFLUENT - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 28/76	25	11	113	31	28	2.6	11	2.8	328	.1	.04	8.2
June 29/76	26	12	126	33	29	4.5	11	2.8	328	.1	.01	8.1
June 30/76	31	13	121	36	33	4.9	12	3.0	340	.1	.01	8.2
Average	27	12	120	33	30	4.0	11	2.9	113	.1	.02	8.2

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XIV

FACILITY #III - STABILIZATION POND #2 (POND FILLING - GRAB SAMPLES TAKEN AT EFFLUENT END)

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 29/76	18	5	88	21	14	1.6	5.4	2.7	252	.1	.02	7.9
June 30/76	16	6	78	16	15	2.2	5.8	2.7	252	.1	.02	7.9
July 1/76	42	20	144	39	34	2.4	7.2	2.8	252	.2	.02	8.2

Unless indicated otherwise, all units, except pH, are mg/L

oxygen demand of the anaerobically decomposing bottom sludge (30 cm throughout) resulted in a total oxygen demand that greatly exceeded the capacity of the aerators. The anaerobic conditions within the aeration cell resulted in nuisance odours but did not seriously affect the performance of the aeration cell. BOD_5 and suspended solids reductions averaged 67% and 79% respectively and the corresponding aeration cell effluent concentrations averaged 112 mg/L BOD_5 and 135 mg/L suspended solids. The aeration cell detention time averaged 7.1 days.

Since the two stabilization ponds were operated in series, pond No. 1 and No. 2 received loads of 24.2 kg BOD_5/ha/d (21.5 lbs BOD_5/acre/day) and 5.2 kg BOD_5/ha/d (4.6 lbs BOD_5/acre/day) respectively. Dissolved oxygen levels ranged from 0.2 mg/L - 0.7 mg/L in pond No. 1 and 1.1 mg/L - 2.1 mg/L in pond No. 2.

6.2.3 Survey # 2

The second sampling survey was carried out from September 7, 1976 to September 13, 1976. Due to mechanical failure, the two aerators were out of service for about three weeks prior to the second sampling survey. The raw sewage was pumped directly to the two waste stabilization ponds during that time. A dense algal growth had developed in the aerated cell during the period of raw sewage bypass to the stabilization ponds.

The aerated cell was put back in operation a week prior to the survey and the effluent from the aerated cell was directed to both stabilization ponds. Pond No. 1 (normally first in series) discharged to pond No. 2 through an interconnecting transfer pipe. Both ponds had reached the maximum operating level and effluent was being discharged from pond No. 2 to the receiving stream. Refer to Tables XV - XVII inclusive.

TABLE XV

FACILITY III - RAW SEWAGE - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	pH	Flow m^3/d	BOD_5 Loading kg/d
Sept. 7-8/76	330	35	583	410	367	7.2	799	264
Sept. 9/76	163	75	289	224	170	7.1	890	145
Sept. 10/76	225	94	350	256	198	7.0	759	171
Average	239	68	407	297	245	7.1	816	193

FACILITY #III - RAW SEWAGE - GRAB SAMPLES

Sept. 7/76						
10:30 a.m.	319	125	470	1095	981	7.0
11:30 a.m.	551	145	534	837	758	7.1
2:30 p.m.	800	170	1017	659	542	7.2
Sept. 8/76						
10:40 a.m.	363	200	607	231	198	6.3
1:00 p.m.	157	66	362	169	137	7.0
2:30 p.m.	172	85	323	190	114	6.9
Sept. 9/76						
8:30 a.m.	137	49	260	198	158	7.9
11:30 a.m.	260	95	478	218	178	7.0
2:30 p.m.	161	67	344	189	150	7.2
Sept. 10/76						
10:00 a.m.	198	105	288	206	160	7.4
11:00 a.m.	318	255	463	227	183	7.1

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XVI

FACILITY #III - AERATION CELL EFFLUENT - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	pH
Sept. 7/76	70	23	315	208	182	8.1
Sept. 8/76	63	11	276	191	165	8.0
Sept. 9/76	74	16	283	188	162	8.3
Sept. 10/76	70	16	240	177	148	8.0
Average	69	17	279	191	164	8.1

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XVII

FACILITY #III - STABILIZATION POND #1 - EFFLUENT - GRAB (DISCHARGING TO LAGOON #2)

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	pH
Sept. 10/76	32	5	134	74	65	8.4

FACILITY #III - STABILIZATION POND #2 - EFFLUENT - GRAB (DISCHARGING TO RECEIVING STREAM)

Sept. 10/76	9	3	76	19	13	7.8

Unless indicated otherwise, all units, except pH, are mg/L

6.2.4 Results And Discussion

Although algae was present in the aerated cell and mechanical changes had been made to the aerators by the supplier to improve their oxygen transfer efficiency, dissolved oxygen could not be maintained in the aerated cell. A dissolved oxygen level of 3.8 mg/L could be found only on Monday, September 13, 1976 after the two major industries in town had shut down for the weekend. Oxygen utilization rates as high as 15 mg O_2/L/hr were measured in the aeration cell, translating into a total oxygen demand of 2,070 kg O_2/d (4,560 lbs O_2/day), exceeding the rated aerator oxygen transfer capacity of 490 kg O_2/d (1,080 lbs O_2/day) by a wide margin. The organic load as computed from the raw sewage flows and BOD_5 concentrations, averaged 193 kg BOD_5/d (425 lbs BOD_5/day) and is well below the design load of 279 kg BOD_5/d (614 lbs BOD_5/day) . The composite samples, however, do not seem to reflect the total daily organic load to the aeration cell. Raw sewage grab samples taken on-site indicate that slugs of waste with very high BOD_5 and suspended solids concentrations are entering the aeration cell periodically. The anaerobically decomposing bottom sludge (30 cm - 40 cm in September) (12 - 14 inches), must account for a substantial part of the total oxygen demand within the aerated cell. BOD_5 and suspended solids reductions, as calculated for the period September 7, 1976 to September 10, 1976, averaged 71% and 36% respectively. The corresponding aerated cell effluent concentrations were 70 mg/L BOD_5 and 191 mg/L suspended solids. Discharging raw sewage directly to the stabilization ponds during the three weeks the aerators were out of service did not seem to affect the performance of the ponds since dissolved oxygen levels in excess of 4.0 mg/L were measured in the ponds throughout the sampling period. The final effluent quality was fair at 9.0 mg/L BOD_5 and 19.0 mg/L suspended solids.

6.3 Conclusions And Recommendations

1. The aerated facultative cell at the treatment facility # III reduces the organic load to the waste stabilization ponds sufficiently even under anaerobic conditions. Aerators with larger oxygen transfer capacity should be installed, however, to overcome the severe odour problems.
2. An extensive sampling survey is necessary to determine the actual total oxygen demand of the combined domestic - industrial waste. The 5-day BOD does not reflect the long term oxygen demand of the waste if high concentrations of biodegradable settleable solids are present. Determination of the 20-day BOD should be carried out during future surveys.
3. To prevent overloading of either waste stabilization pond, the ponds should be operated in parallel at all times.

7.0 Evaluation Of Treatment Facility # IV

7.1 Description Of Works

The treatment facility consists of an aerated cell (4.4 acres) followed by two waste stabilization ponds each with approximately 4 ha (10 acres) of surface area with provisions for either parallel or series operation. The aerated cell has an operating depth of 3m (10 feet). The aeration cell detention time at the design flow of 1,727 m^3/d (0.38 MIGD) is 27 days (winter operation). Four 14.9 kW (20 HP) mechanical surface aerators are designed to deliver a total of 119 kg (262 ponds) of oxygen per hour. The corresponding mixing power is 1.3×10^{-3} kW/m^3 (0.05 HP/1,000 cu ft) of aeration cell volume. Up to 1.8 m (6 feet) of operating depth can be provided in the waste stabilization ponds. At an operating depth of 1.8 m (6 feet) and the design (winter) flow of 1,727 m^3/d (0.38 MIGD), the stabilization ponds provide 80 days detention. After discharge of the contents of the waste stabilization ponds in March or April, total waste detention is practiced until October. From October until April, with the local fruit processing plant in operation, the facility is operated in the continuous discharge mode with the two stabilization ponds being operated in series. During 1976 phosphorus removal was not required at this location.

7.2 Sampling Surveys

The facility was first visited on March 25, 1976. The system was at that time operated in the continuous discharge mode. Grab samples of the raw sewage, the aeration cell effluent and the effluents of the stabilization ponds were taken. Dissolved oxygen measurements indicated sufficient oxygen levels in the aerated cell (8.4 mg/L). The South (first in series) stabilization pond had a marginal DO concentration of 0.6 mg/L and no dissolved oxygen could be detected in

the north stabilization pond effluent (final effluent). Hydrogen sulfide odours were noticeable at the final effluent discharge structure indicating anaerobic conditions in the north stabilization pond. Both stabilization ponds had a complete cover of ice and snow at the time of the visit.

7.2.1 Survey # 1

The first sampling and testing program was carried out from June 14, 1976 to June 18, 1976. The local fruit processing plant was not in operation at that time. The system was operated in the total detention mode. The two stabilization ponds were filling up and were at an operating level of about three feet. Only weak domestic wastewater, indicating sewer infiltration, was received at the treatment facility.

During the summer months, the number of aerators in operation is manually controlled according to the dissolved oxygen concentration (> 5.0 mg/L) in the effluent from the aerated cell and only one of the four aerators was needed at this time. Some algae growth was noticeable in the aerated cell and the south stabilization pond. Although very little algae was detectable in the north (final) stabilization pond, the dissolved oxygen concentration remained in excess of 4.0 mg/L. No odours were evident. Sludge accumulations of 7-10 cm (3-4 inches) were found only near the inlet to the aerated cell. Refer to Tables XVII to XXIII inclusive.

7.2.2 Results And Discussion

The following average organic loadings were calculated for the sampling period June 14, 1976 to June 18, 1976:

TABLE XVIII

FACILITY #IV - RAW SEWAGE - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	Flow m^3	BOD_5 Loading kg/d	pH
June 14/76	50	12	148	75	54	3.6	8.8	2.3	252	.01	<.1	1,136	57	7.4
June 15/76	72	14	371	167	105	2.7	9.6	2.2	208	<.1	.02	1,136	82	7.4
June 16/76	86	32	239	157	115	3.0	12	2.8	260	.1	.01	929	79	8.1
June 17/76	62	16	143	117	77	5.9	12	2.7	252	.01	<.1	826	51	-
Average	68	19	225	129	88	3.8	11	2.5	243	<.1	<.1	1,075	72	7.8
Oct. 11/76	809	491	1180	558	202	3.9	23	5.8	132	0.10	0.1	1,110	896	6.5
Oct. 12/76	730	370	1466	487	188	.1	12	6.4	84	.04	.01	1,214	885	5.5
Oct. 13/76	950	408	1680	607	236	0.2	13	3.7	70	0.9	.01	1,265	1,200	5.4
Oct. 14/76	870	400	1274	701	238	.1	15	4.4	90	0.4	0.02	1,324	1,150	5.6
Average	840	417	1400	588	216	2.1	16	5.0	94	0.5	<.1	1,228	1,033	5.5

Unless indicated otherwise, all units, except pH, are mg/l

TABLE XIX

FACILITY #IV - RAW SEWAGE - GRAB SAMPLES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
March 25/76	435	360	893	302	206	4.0	8.8	2.0		<.1	<.1	
June 14/76	88	47	278	121	86	7.8	15	4.1	262	-	-	7.6
June 15/76	10	4	30	10	7	2.4	3.6	0.44	236	0.6	.3	7.8
June 16/76	10	3	33	18	12	5.8	6.2	0.68	236	.7	.15	8.1
Oct. 12/76	418	198	686	158	101	3.6	11	4.5	196	0.2	<.01	6.0
Oct. 13/76	72	35	138	68	44	2.7	8.0	1.8	220	<.1	<.01	7.1
Oct. 14/76	168	84	333	225	128	4.7	17	2.7	260	<.1	.01	6.6
March 25/77	1125	770		130	94	6.1	9.5	12.2	336	0.5	0.01	7.2

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XX

FACILITY #IV - AERATED CELL EFFLUENT - 24 HOUR COMPOSITE

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 14/76	42	4	84	34	28	4.6	9.6	2.7	276	.63	0.2	8.4
June 15/76	42	5	84	36	31	4.7	9.6	2.6	280	.2	.61	8.3
June 16/76	38	4	81	41	33	5.0	9.4	2.7	276	.5	.63	8.3
June 17/76	36	5	83	32	27	5.1	9.8	2.8	276	.56	.4	8.3
Average	40	5	83	36	30	4.9	9.6	2.7	277	0.5	0.5	8.3
Oct. 11/76	44	8	92	24	18	3.9	5.2	3.2	256	0.10	0.01	7.5
Oct. 12/76	40	8	80	23	16	3.1	5.4	3.3	260	<.1	.01	7.5
Oct. 13/76	48	12	87	29	17	3.3	5.5	3.3	260	<.1	< .01	7.5
Average	46	9	86	25	17	3.4	5.3	3.3	259	<.1	.01	7.4

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XXI

FACILITY #IV - AERATED CELL EFFLUENT - GRAB SAMPLES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
March 25/76	47	10	177	104	102	<.1	5.8	0.9	236	< .1	<.01	
June 14/76	38	5	85	33	27	7.2	9.6	2.6	276	-	-	8.4
June 15/76	42	4	84	37	33	5.2	10.0	3.4	276	.5	.1	8.3
June 16/76	37	4	86	42	48	5.3	9.8	2.6	280	.2	.46	8.3
Oct. 15/76	47	23	145	52	28	< .1	5.5	3.4	254	<.1	0.01	7.1
Oct. 12/76	25	8	89	26	19	0.9	5.2	3.2	260	<.1	0.01	7.3
Oct. 13/76	29	9	86	29	21	0.2	4.8	3.2	260	<.1	.01	7.4
Oct. 14/76	31	15	98	38	27	< .1	5.5	3.3	256	<.1	<.01	7.5
March 25/77	59	13	-	89	81	< .1	6. 0	1.9	256	<.1	<.01	

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XXII

FACILITY #IV - STABILIZATION POND #1 CONTENTS - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 14/76	25	2	100	47	49	< .1	3.6	1.1	220	.0	<.1	9.2
June 15/76	20	3	76	39	34	< .1	3.2	0.88	260	< .1	.02	9.0
June 16/76	17	3	74	41	32	0.1	4.0	1.2	224	< .1	.02	9.1
June 17/76	22	3	77	37	29	0.2	3.8	1.2	224	.02	<.01	9.1
Average	21	3	82	41	33	0.1	3.7	1.1	231	< .1	<.1	9.1

FACILITY #IV - STABILIZATION POND #1 - GRAB SAMPLES

March 25/76	36	15	110	38	37	.1	5.4	0.9	236	< .1	< .1	-
June 14/76	11	3	62	23	19	0.6	2.8	0.84	220	-	-	9.2
June 15/76	12	3	62	25	21	.1	3.0	0.92	220	< .1	< .1	9.0
June 16/76	13	4	52	31	24	0.1	3.2	0.40	216	< .1	.01	9.1
Oct. 12/76	3	3	32	3	2	0.2	1.8	1.2	232	0.8	0.05	8.3
Oct. 13/76	5	3	33	7	5	0.2	1.8	1.2	248	0.9	.05	8.0
Oct. 14/76	4	2	32	7	1	0.2	2.0	1.2	228	0.9	.04	8.0
Oct. 15/76	3	2	34	9	2	0.2	1.8	1.2	232	1.0	.04	8.0
March 25/77	42	10	-	74	74	0.1	5.0	1.8	256	< .01	< .1	7.1

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XXIII

FACILITY #IV - STABILIZATION POND #2 - CONTENTS - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
June 14/76	8	3	50	8	5	<.1	1.8	0.48	228	<.1	.01	8.3
June 15/76	9	3	54	11	8	<.1	1.6	0.36	224	<.1	.01	8.2
June 16/76	7	3	53	9	6	<.1	1.6	0.44	224	<.1	.02	8.3
June 17/76	8	3	53	7	6	<.1	1.6	0.40	224	<.1	.01	8.3
Average	8	3	53	9	6	< 0.1	1.6	0.4	225	<.1	.1	8.3

FACILITY #IV - STABILIZATION POND #2 - GRAB SAMPLES

March 25/77	28	12	97	33	31	< .1	5.4	0.84	224	< .1	0.1	-
June 14/76	4	3	47	6	3	0.7	1.6	0.32	228	-	-	8.3
June 15/76	6	3	49	6	4	0.2	1.8	0.40	232	< .1	.01	8.2
June 16/76	7	4	52	11	6	.03	1.8	0.40	228	< .1	.01	8.3
Oct. 12/76	3	2	33	1	1	< .1	1.4	0.60	216	0.2	0.02	7.8
Oct. 13/76	3	2	32	6	3	<.1	1.2	0.64	216	0.2	.02	8.4
Oct. 14/76	3	2	30	7	1	<.1	1.4	0.64	216	0.2	.02	8.4
Oct. 15/76	5	2	34	12	1	<.1	1.4	0.64	218	0.3	.02	8.4
March 25/77	26	7	-	34	33	0.1	4.0	2.3	260	< .1	< .01	7.1

Unless indicated otherwise, all units, except pH, are mg/L

Aerated Cell	:	1.6 g $BOD_5/m^3/d$ (0.1 lb BOD_5/1,000 cu ft/day);
South Stabilization Pond	:	10.9 kg BOD_5/ha/d (9.7 lbs BOD_5/acre/day);
North Stabilization Pond	:	5.5 kg BOD_5/ha/d (4.9 lbs BOD_5/acre/day)

Although the organic load to the aerated cell was very low and the detention time averaged 44 days, a BOD_5 reduction of only 41% was realized. The corresponding suspended solids reduction averaged 72%. Additional reductions in BOD_5 and suspended solids occurred during storage of the wastewater in the stabilization ponds.

7.2.3 Survey # 2

The second sampling survey was carried out from October 11, 1976 to October 15, 1976. The local industry had commenced with fruit processing and the treatment facility was operated in the continuous discharge mode with the stabilization ponds operated in series. As during the previous survey, no odours and only minor sludge accumulations could be detected. Refer to Tables XVIII to XXIII inclusive.

7.2.4 Results And Discussion

The analytical results for this sampling period show that high strength waste was entering the treatment facility. The local fruit processing plant had started operation above two weeks prior to the survey. No improvements to the Towns sewage collection system to reduce infiltration had been made since the first survey and the change in waste strength must be attributed to the waste being discharged by the industry. Only two aerators were in operation at the start of the survey and low (0.3 mg/L) dissolved oxygen levels were detected in the aerated cell. A third aerator had to be put

into operation to maintain dissolved oxygen levels above 1.0 mg/L. The average load entering the aerated cell was 1,033 kg BOD_5/d (2,275 lbs BOD_5/day) requiring 1,550 kg O_2/d (3,413 lbs O_2/day) assuming an oxygen demand of 1.5 kg O_2/kg BOD_5 (1.5 lbs O_2/lb BOD_5) applied. According to the design specification for this facility, three aerators should be capable of delivering 2,141 kg O_2/d (4.715 lbs O_2/day).

The average load of 1,033 kg BOD_5/d (2,275 lbs BOD_5/day) represents 56% of the design load of 1,843 kg BOD_5/d (4,060 lbs/day). The corresponding average daily organic load was 22.4 g BOD_5/m^3/d (1.4 lb BOD_5/1,000 cu ft/day) of aeration cell. An average of 70% of the design flow of 1,727 m^3/d (0.38 MIGD) was measured during the same period resulting in an aeration cell detention time of 38 days.

The analytical results for this sampling period do not reflect the full impact that the waste from the fruit processing plant has on the performance of the aeration cell and stabilization ponds during winter operation. The industry had commenced with fruit processing only 15 days prior to the survey and the aeration cell detention time averaged 38 days.

Further samples taken in March 1977 indicate that the performance of the facility had suffered during winter operation. With four aerators in operation, the aeration cell effluent DO was 1.0 mg/L. The stabilization ponds were void of dissolved oxygen and strong hydrogen sulfide odours were noticed at the final effluent structure.

7.3 Conclusions And Recommendations

1. No changes in operation are presently required for the total waste detention period (April - October) since the system has ample capacity to assimilate the organic load

from the domestic sewage.

2. A meaningful performance evaluation of the aerated cell can not be made for the second sampling period since the first processing industry had commenced operation only 15 days prior to the second survey and the detention time of the aerated cell averaged 38 days.

3. Supplementary aeration of the stabilization ponds may be necessary during winter operation (continuous discharge) to prevent anaerobic conditions that result in strong nuisance odours and possibly toxic H_2S concentrations in the receiving water.

4. To determine the actual organic load that the fruit processing industry discharges to the treatment facility, composite samples over 24 hours should be taken of the industrial waste stream together with accurate flow measurements.

8.0 Evaluation Of Treatment Facility # V

8.1 Description Of Works

This wastewater treatment facility consists of two identical aerated, facultative cells operated in parallel followed by a polishing pond. The aerated cells have a total volume of 19,258 m^3 (680,000 cu ft) at an operating depth of 3 m (10 feet). The average detention time is 9 days at the design flow of 2,136 m^3 (470,000 IGPD). The design organic load is 463 kg BOD_5/d (1,020 lbs BOD_5/day) resulting in a load of 24 g $BOD_5/m^3/d$ (1.5 lbs BOD_5/1,000 cu ft/day) to the aeration cells. Aeration is provided by four 7.5 kW (10 HP) surface aerators with a rated oxygen transfer efficiency of .3 kg/MJ·h (2.0 lbs O_2/HP/hr). The resulting mixing power is about $1.6X10^{-3}$ kW/m^3 (0.06 HP/1,000 cu ft) of aeration cell volume. The combined effluents from the aeration cells flow to a polishing pond with a surface area of 6 ha (15 acres) and an operating depth of 1.5 m (5 feet). The polishing pond provides about 43 days detention at the above design flow. Phosphorus reduction is accomplished by ferric chloride addition to the polishing pond influent.

8.2 Sampling Surveys

During the first visit on March 24, 1976 the aerated cells were completely free of ice and only about 50% of the polishing pond was still under a cover of ice. Dissolved oxygen concentrations of 7.6 mg/L and 6.0 mg/L were measured in aeration cells 1 and 2 respectively.

The polishing pond effluent had a dissolved oxygen concentration of 4.8 mg/L. The system seemed to be performing satisfactorily and no odours could be detected.

8.2.1 Survey # 1

The first survey was conducted from July 19, 1976 to July 22, 1976. The local dill pickling industry was not in production at that time and mainly domestic sewage was entering the treatment facility. Composite samples over 24 hours were collected of the raw sewage and the two aeration cell effluents and grab samples were taken of the polishing lagoon effluent. On-site tests included pH, dissolved oxygen, temperature and oxygen utilization rates and measurement of bottom sludge accumulations. Refer to Tables XXIV - XXVII inclusive.

8.2.2 Results And Discussion

As calculated from the results presented in the tables, the average load to the aeration cells during the first survey was only 9.6 g $BOD_5/m^3/d$ (0.6 lb BOD_5/1,000 cu ft/day). The corresponding combined aeration cell detention time was about 10.0 days at an average flow of 1,895 m^3/d (417,100 IGPD) and the resulting BOD_5 and suspended solids reductions were 62.5% and 80.7% respectively. The highest single day organic load was 241 kg BOD_5 (530 lbs BOD_5), which represents about 50% of the design load. Dissolved oxygen concentrations in the aeration cells ranged from 3.9 mg/L - 6.5 mg/L for the duration of the survey. Oxygen utilization rates of the aeration cell contents were very low and could not be measured accurately. The oxygen transfer efficiency of the mechanical surface aerators could therefore not be determined. Aeration cell bottom sludge accumulations were in the order of 10 cm - 15 cm (4 - 6 inches). The combined aeration cell effluents averaged 35.0 mg/L BOD_5 and 34.0 mg/L suspended solids. The performance of the polishing pond could not be predicted accurately because of the short sampling period and relatively long detention time (47 days).

TABLE XXIV

FACILITY #V - RAW SEWAGE - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	Flow m^3/d	BOD_5 Loading kg/d	pH
July 19/76	120	37	307	226	165	11	24	6.4	308	.1	<.01	1,724	206	-
July 20/76	110	24	253	249	160	8.4		4.8	256	<.1	<.01	2,192	240	7.6
July 21/76	70	19	165	119	94	11	19	3.9	296	<.1	<.01	1,828	128	7.8
July 22/76	74	23	189	117	94	8.9	16	4.0	296	<.1	<.01	1,849	137	7.6
Average	94	26	229	177	128	10	20	4.8	289	.1	.01	1,898	178	7.7
Aug. 10/76	237	133	382	214	170	8.5	22	6.2	236	<.1	0.01	2,200	520	7.4
Aug. 11/76	187	112	317	247	170	9.2	24	6.0	276	0.1	0.01	2,250	420	7.0
Aug. 12/76	195	88	297	255	166	12	21	4.8	288	0.1	<.01	2,137	416	7.6
Average	206	111	332	239	169	10	22	5.7	267	0.1	0.01	2,196	452	7.3

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XXV

FACILITY #V - WEST AERATION CELL EFFLUENT - GRAB SAMPLES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
July 19/76	24	16	74	17	14	19	22	4.0	328	.3	.10	7.5
July 20/76	23	13	68	18	16	18	21	4.2	324	.3	.10	7.6
Aug. 11/76	33	12	125	75	66	6.6	15	4.6	286	<.1	.02	7.7
Aug. 12/76	37	11	122	84	74	7.8	18	4.4	288	<.1	.06	7.7
FACILITY #V - EAST AERATION CELL EFFLUENT - GRAB SAMPLES												
July 19/76	35	4	77	30	24	20	22	4.2	332	.41	-	7.8
July 20/76	34	5	74	27	22	20	22	4.4	336	.2	.45	7.6
Aug. 11/76	64	11	78	41	36	3.4	6.4	3.8	264	1.9	2.3	7.7
Aug. 12/76	51	12	69	36	32	1.7	4.4	3.9	256	0.9	5.3	7.6

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XXVI

FACILITY #V - WEST AERATION CELL EFFLUENT - 24 HOUR COMPOSITES

Date	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
July 19/76	25	14	83	29	26	17	20	4.0	324	.5	.10	7.7
July 20/76	24	12	93	32	28	17	33	4.0	316	.3	.10	7.7
July 21/76	20	11	89	41	36	15	18	3.6	300	.4	.10	7.7
July 22/76	21	9	81	35	30	15	19	3.6	300	.4	.10	7.8
Average	23	12	87	34	30	16	23	3.8	310	.4	.10	7.7
Aug. 10/76	35	12	121	83	75	6.5	16	4.2	284	<.1	.05	8.0
Aug. 11/76	32	12	134	89	79	5.5	16	4.4	280	<.1	.02	8.1
Aug. 12/76	34	12	118	94	83	6.6	17	4.0	288	<.1	.05	8.0
Average	34	12	124	89	79	6.2	16	4.2	284	<.1	.04	8.0
FACILITY #V - EAST AERATION CELL EFFLUENT - 24 HOUR COMPOSITES												
July 20/76	52	5	89	40	33	19	18	4.6	320	.4	.82	7.4
July 21/76	43	6	87	33	27	18	20	4.0	320	.3	.68	7.9
July 22/76	44	6	81	31	26	17	20	4.0	320	.20	.94	7.7
Average	47	6	86	35	29	18	19	4.2	320	.3	.82	7.7
Aug. 10/76	63	15	87	52	48	4.5	10	4.4	268	0.6	4.4	7.7
Aug. 11/76	63	14	100	53	47	2.0	12	4.2	256	2.6	2.6	8.1
Aug. 12/76	56	12	81	55	49	0.6	6.0	4.2	256	2.2	4.6	7.9
Average	61	14	89	53	48	2.4	9	4.3	260	1.8	3.9	7.9

Unless indicated otherwise, all units, except pH, are mg/L

TABLE XXVII

FACILITY #V - STABILIZATION POND EFFLUENT - GRAB SAMPLES

DATE	BOD_5	Filt. BOD_5	COD	SS	VSS	NH_3-N	TKN	Total P	Alk. as $CaCO_3$	NO_3-N	NO_2-N	pH
July 19/76	15	3	102	67	53	.1	5.8	1.8	204	.1	.01	9.3
July 20/76	12	2	84	67	55	.1	5.2	1.6	208	0.1	.01	9.1
July 21/76	13	3	92	62	53	0.9	6.6	1.7	208	.1	.06	9.2
July 22/76	9	2	80	52	42	1.0	6.4	1.7	204	.1	.06	9.2
AVERAGE	12	3	90	62	51	0.5	6.0	1.7	206	.1	.04	9.2
Aug. 10/76	12	2	74	41	37	0.6	4.8	1.8	200	0.1	0.35	9.3
Aug. 11/76	11	2	75	42	36	0.1	3.8	1.6	200	0.2	0.40	9.2
Aug. 12/76	14	3	65	43	35	0.4	3.8	1.6	204	0.2	0.38	9.2
Average	12	2	71	42	36	0.4	4.1	1.7	201	0.2	0.38	9.2

Unless indicated otherwise, all units, except pH, are mg/L

An average of about 11.2 kg BOD_5/ha/d (10 lbs BOD_5/acre/day) was applied during the first survey and the polishing pond effluent averaged 12.0 mg/L BOD_5. The polishing pond effluent suspended solids concentration, however, averaged 62.0 mg/L due to dense algae growth. It seems that in regards to suspended solids, polishing pond effluents can be of inferior quality to pond influents during periods of stimulated algae growth. The high effluent total phosphorus concentration (1.7 mg/L P) was probably caused by a combination of high effluent suspended solids and the lack of control and supervision over chemical feed rates and dosage.

8.2.3 Survey # 2

The second survey was carried out from August 10, 1976 to August 12, 1976 in order to evaluate the performance of the treatment facility during dill pickle production by the local industry and the resulting increase in wastewater strength and volume.

Sampling and testing procedures were identical to the first survey and the treatment facility was operated in the same manner as during the previous survey. Refer to Tables XXIV - XXVII inclusive.

8.2.4 Results And Discussion

The average daily flow increased by about 15% between surveys to 2,195 m^3/d (483,000 IGPD). The organic load, however, almost doubled to 452 kg BOD_5/d (996 lbs BOD_5/day) due to the additional wastewater from the local industry. The resulting organic load to the aeration cells averaged 19.2 g BOD_5/m^3/d (1.2 lbs BOD_5/1,000 cu ft/day) and BOD_5 reductions of 72.9% and suspended solids reductions of 65.0% were achieved at an aeration detention time of about 9.0 days. The maximum load to the aeration cells was 530 kg BOD_5/d (1,146 lbs BOD_5/day), slightly above the design of 463 kg/d (1,020 lbs/day). Dissolved oxygen levels of 2.6 mg/L - 6.0 mg/L were measured in the aeration cells

throughout the survey. Although the BOD_5 load to the aeration cells increased substantially, actual oxygen utilization rates could still not be determined accurately. The combined aeration cell effluents averaged 47.1 mg/L BOD_5 and 72.0 mg/L suspended solids. The corresponding surface load to the polishing pond was 17 kg BOD_5/ha/d (15.2 lbs BOD_5/acre/day). The pond effluent averaged 12.0 mg/L BOD_5 and 42.0 mg/L suspended solids.

The high suspended solids concentration was again attributed to the noticeably dense alage growth. Final effluent total phosphorus concentrations averaged 1.7 mg/L and this high value may, in part, be due to the high suspended solids concentrations.

8.3 Conclusions And Recommendations

1. The aeration equipment performed satisfactorily at loads close to the design organic load of 463 kg BOD_5/d (1,020 lbs BOD_5/day).
2. Operator supervision of the chemical feed equipment for phosphorus removal should be increased to ensure that the recommended chemical dosage is being applied. Improved phosphorus removal efficiency should result.

9.0 General Conclusions

From the limited data available, (data summary presented in Table XXVIII) the following conclusions can be drawn for aerated facultative cells and completely mixed aerated cells as used in Ontario for the pre-treatment of domestic and combinations of domestic and medium strength industrial wastewaters:

1. The use of aerated facultative and completely mixed aerated pre-treatment cells are a means of reducing the organic load to existing waste stabilization ponds.
2. Neither process produces a secondary treatment quality effluent and direct discharge to a receiving water is normally not acceptable. Additional treatment (stabilization ponds) is therefore required.
3. At comparable organic loads, treatment efficiency in regards to BOD_5 removal is quite similar for both pre-treatment processes. Aerated facultative cells, however, usually produce effluents with considerably lower effluent suspended solids concentrations and thus a reduced rate of sludge accumulation in the stabilization ponds is realized.
4. Operation and maintenance are identical for both modes of pre-treatment.
5. Aerated facultative cells operated in parallel may provide flexibility in operation if seasonal changes in organic loads are encountered, i.e. one cell could be taken out of service during periods of low organic loads. An increase in treatment efficiency, however, is not being realized and the use of two or more aerators in a single cell provides the same operational flexibility at a lower initial capital cost.

TABLE XXVIII

* A - DESIGN
** B - ACTUAL

PERFORMANCE SUMMARY OF AERATION CELLS

Date	Facility	Organic Load g $BOD_5/m^3/d$		Detention Time days		Influent mg/L		Effluent mg/L		Removal %		Remarks
		A*	B**	A*	B**	BOD_5	SS	BOD_5	SS	BOD_5	SS	
June 21-23	I	48	21	4.2	6.5	139	250	44	94	67	62	Complete Mixed Cell, Mech. Aerators, Platform Mounted, Domestic Wastewater
July 6- 9	II	117	82	3.5	3.3	273	246	104	164	62	38	Complete Mixed Cell, Floating, Mech. Aerators, Ind. & Dom. Wastewater
Nov. 9-12		117	62.5	3.5	3.6	222	231	106	373	52	-	
June 28-30	III	48	46.5	5.9	7.1	342	635	112	135	67	79	Aerated Facultative Cell, Mech. Aerators, Platform Mounted, Ind. & Dom. Wastewater
Sept. 7-10		48	32	5.9	7.4	239	296	70	191	71	36	
June 14-18	IV	40	1.6	37	44	68	129	40	36	41	72	Aerated Facultative Cell, Platform Mounted Mechanical Aerators, Domestic in June, Ind. & Dom. in October
Oct. 11-15		40	22.4	27	38	840	588	-	-	-	-	
July 19-22	V	24	9.6	9.0	10.0	94	178	34	34	63	81	Aerated Facultative Cells, Platform Mounted Mech. Aerators, Domestic in July, Ind. & Dom. in August
Aug. 21-23		24	19.2	9.0	9.0	206	239	47	72	73	65	

6. Berm erosion is normally not a problem with aerated facultative cells if the mixing intensity is kept below 2.6 W/m^3 (0.1 HP/1,000 cu ft) of aeration cell. Completely mixed cells must be lined (concrete, asphalt, rip-rap, plastic liner) to prevent erosion.
7. Aerated facultative or completely mixed aerated cells used as pre-treatment units do not prevent anaerobic conditions in the waste stabilization ponds that follow during periods of ice and snow cover. The production of hydrogen sulphide during these periods could lead to odour problems and possibly toxic H_2S levels in the receiving waters. Supplementary sub-surface aeration of the waste stabilization ponds for the periods of ice and snow cover may therefore be necessary.
8. Effluent total nitrogen concentrations are similar to influent concentrations for both aerated facultative and completely mixed aerated cells. In aerated facultative pre-treatment cells, however, a substantial increase in ammonia-nitrogen may occur, due to the conversion of organic nitrogen to ammonia in the anaerobically decomposing bottom sludge. A considerable removal of ammonia occurs in the stabilization ponds during ice-free periods due to stripping to the atmosphere, although nitrification does not occur to any extent.

10.0 General Recommendations

1. As a pre-treatment process to reduce the organic load to existing waste stabilization ponds, an aerated facultative cell should be preferred over a completely mixed aerated cell since lower capital and operating costs may be realized. The high mixing power requirements, i.e. 13 W/m^3 of aeration cell volume, and the necessity for berm protection for completely mixed cells may offset any savings derived from a reduction in cell volume due to higher allowable organic loadings. In addition, aerated facultative cells produce effluents with lower suspended solids concentrations since settleable solids deposit and decompose on the cell bottom. As a result, the rate of sludge accumulation and localized overloading is greatly reduced in the stabilization ponds that follow.
2. In regards to phosphorus removal, chemical addition to the stabilization pond influent may be practiced for any type of operational mode, i.e. conventional or aerated facultative, continuous discharge, seasonal and annual detention. For seasonal and annual discharge ponds, however, batch treatment with chemicals should be practiced since an effluent of improved quality would result.
3. It is well established that aerated facultative and completely mixed aerated cells as presently designed and operated in Ontario as pre-treatment units do not prevent anaerobic conditions in the stabilization ponds that follow during periods of ice and snow cover.

3. The presence of toxic levels of hydrogen sulphide in the effluent may therefore require the conversion of the stabilization ponds to aerated facultative ponds. The availability of aeration equipment for sub-surface aeration with diffused air makes this conversion simple and economical since such capital expenditures as costs for land acquisition, excavation, etc, are eliminated. Operating costs should be similar to those of aerated facultative pre-treatment cells since oxygen and the resulting power requirements are based primarily on the organic load (kg BOD_5/day) in both instances (1).

4. For treatment systems consisting of:

   (a) an aerated facultative pre-treatment cell followed by conventional stabilization ponds;

   (b) a completely mixed aerated pre-treatment cell followed by conventional stabilization ponds, or

   (c) stabilization ponds converted to aerated facultative ponds, a net increase of ammonia-nitrogen may occur during the winter months due to conversion of organic nitrogen to ammonia in the anaerobic bottom sludge. If very low final effluent ammonia concentrations are required for winter (continuous) and spring (batch) discharge, a simplified (no sludge wasting) extended aeration system should precede the conventional stabilization ponds (2). A nitrified and well stabilized effluent would be discharged to the ponds resulting in very low organic loadings and therefore a low oxygen demand. During periods of ice and snow cover without surface aeration and the

absence of algae, the nitrates would be the oxygen donors resulting in de-nitrification producing an effluent with low total nitrogen concentrations.

5. Basic design criteria for all of the above mentioned treatment processes are well established at this time (3), and will not be repeated here. It it recommended, however, that aeration equipment used in any one of the processes should be installed in multiple units to provide flexibility of operation that could result in substantial savings in electrical power costs.

11.0 References

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